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(54) **TRASH SEPARATOR**

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B07B 7/00	(2006.01)
D01B 3/00	(2006.01)

(52) **U.S. Cl.**
USPC **209/139.1**; 19/200

(58) **Field of Classification Search**
USPC .... 19/200, 204, 66 CC, 100, 107, 108, 19/109, 112, 218, 233; 209/138, 139.1, 142
See application file for complete search history.

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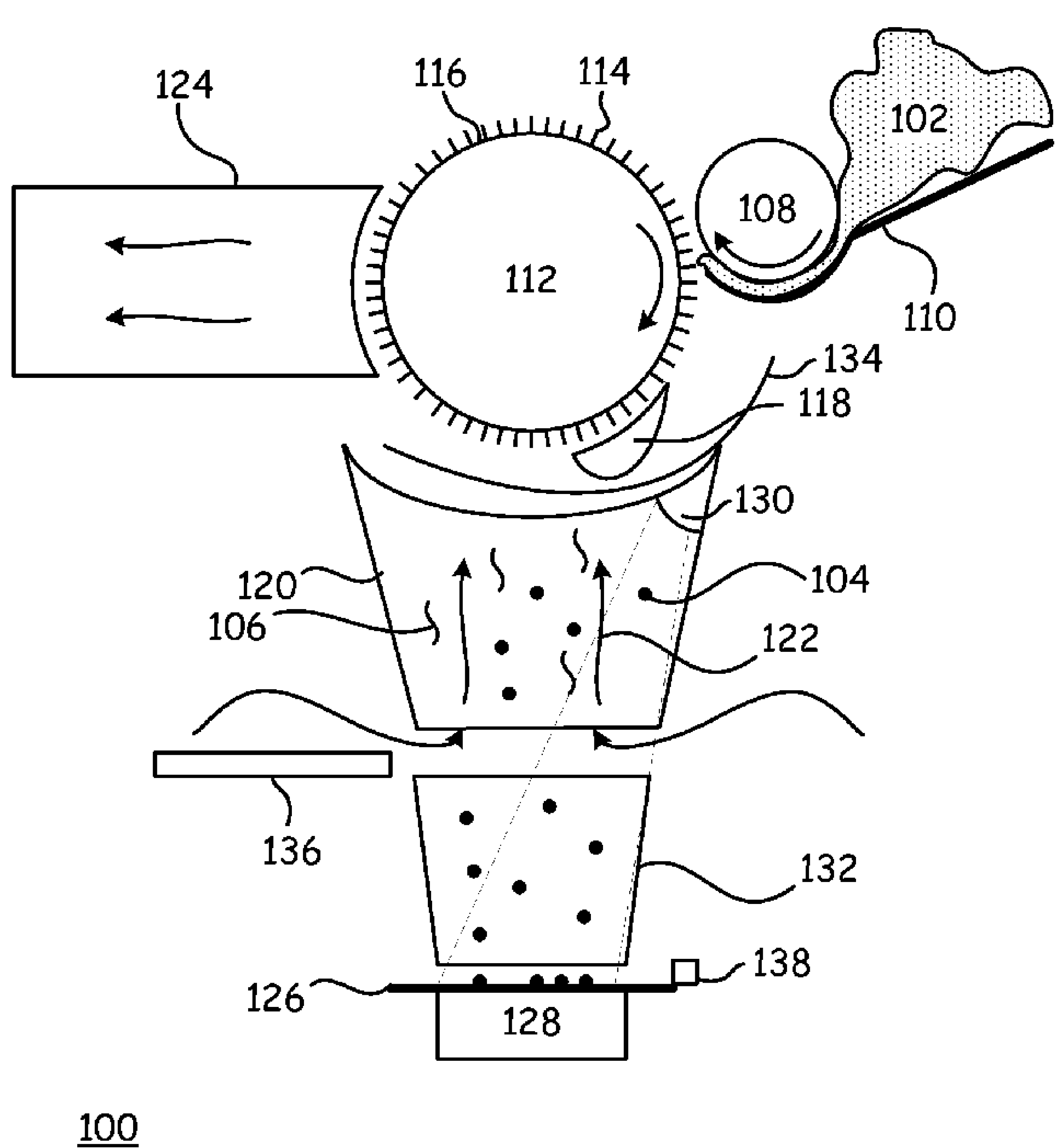
(57) **ABSTRACT**

An apparatus for processing a sample of fibers and trash, having a cylinder for receiving the sample. Pins extend from the surface of the cylinder and retain the fibers. A knife extends along the cylinder adjacent the pins, and removes the trash that is not retained by the pins. The trash is separated from the sample along a downward direction. A counter-flow of air in an upward direction is directed towards the cylinder, where the velocity is sufficient to blow the fibers that are not originally retained by the pins up toward the cylinder, and yet is insufficient to prevent gravity from pulling the trash downward.

20 Claims, 2 Drawing Sheets



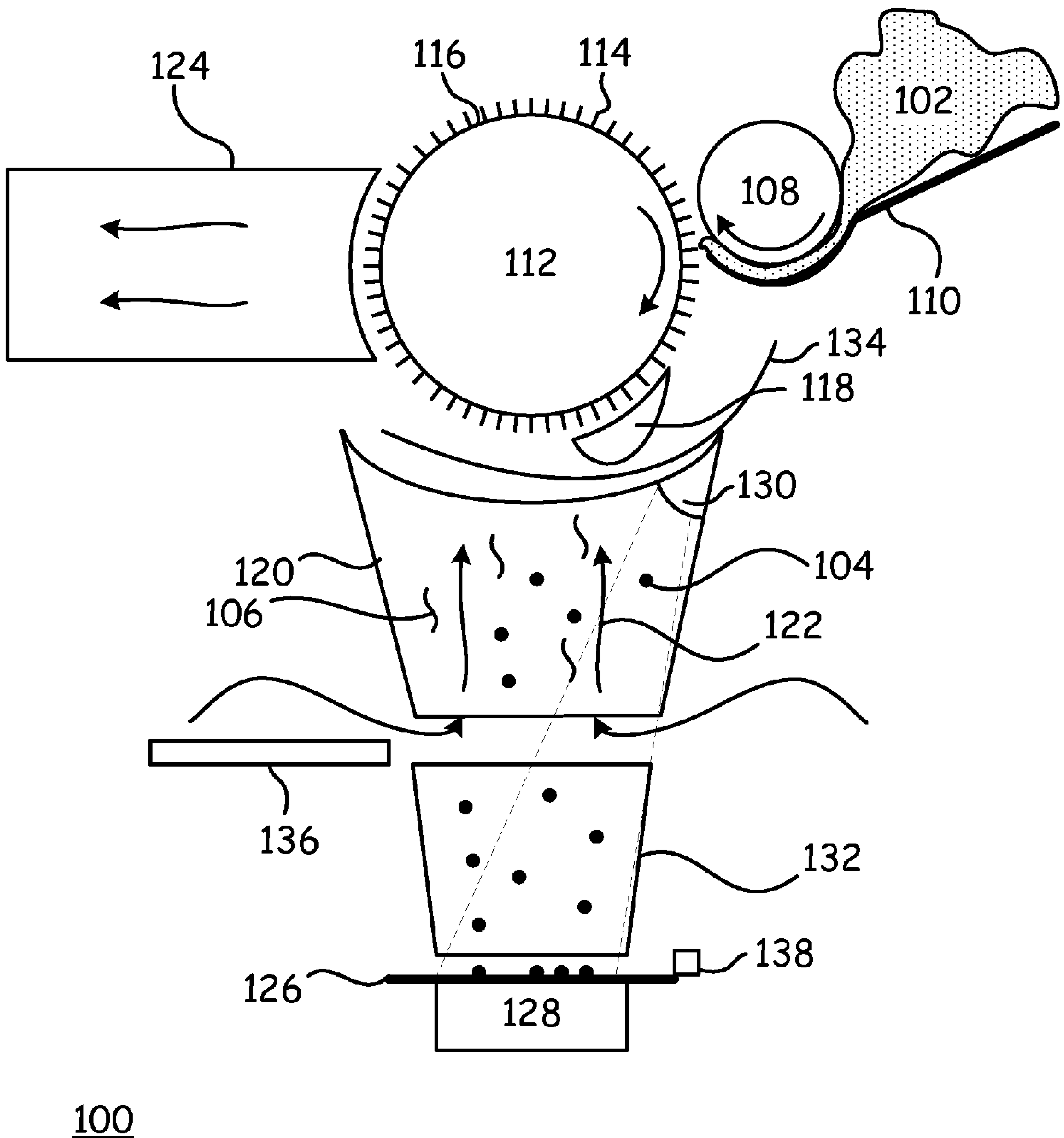

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Fig. 1

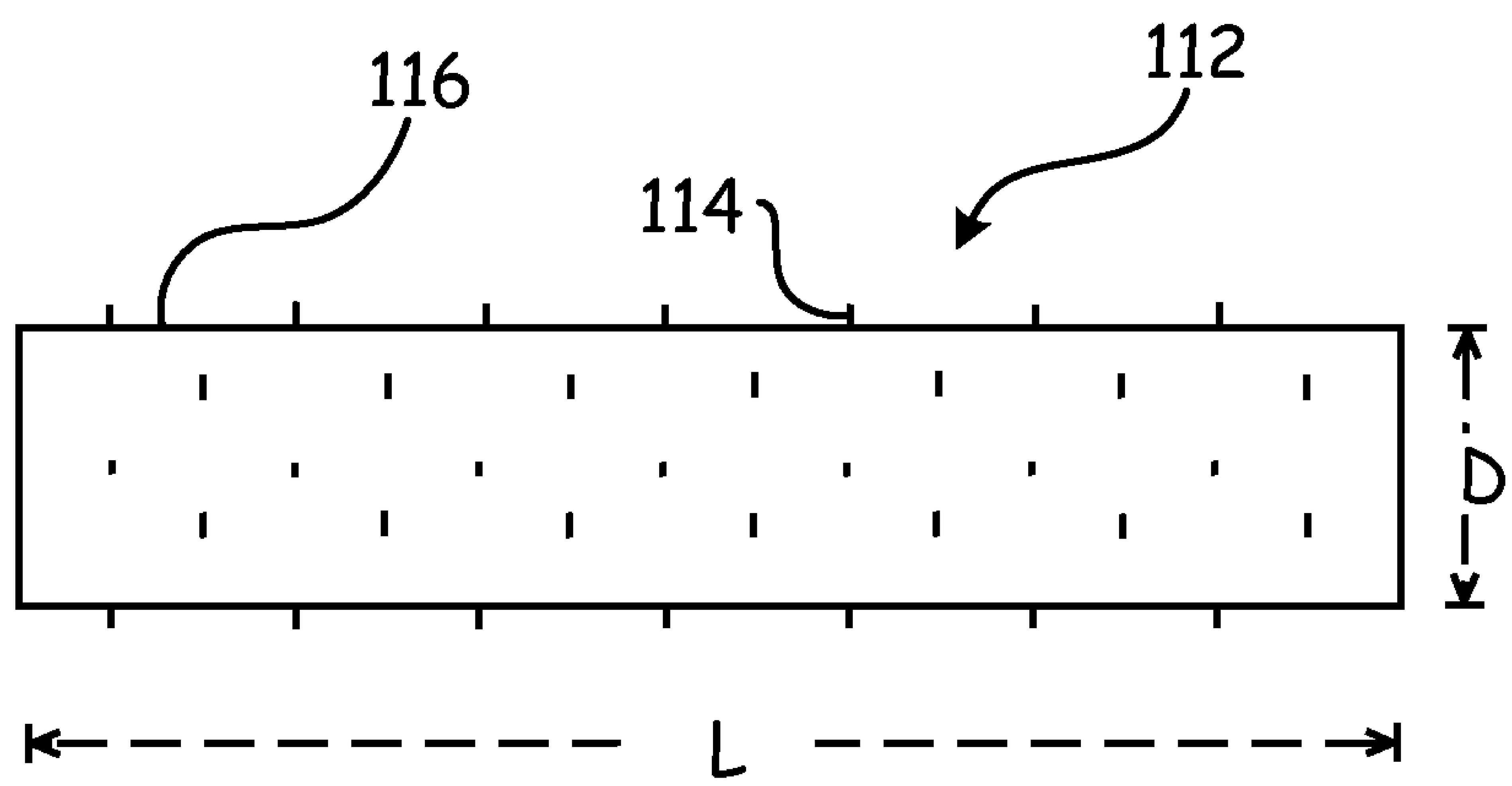

Fig. 2

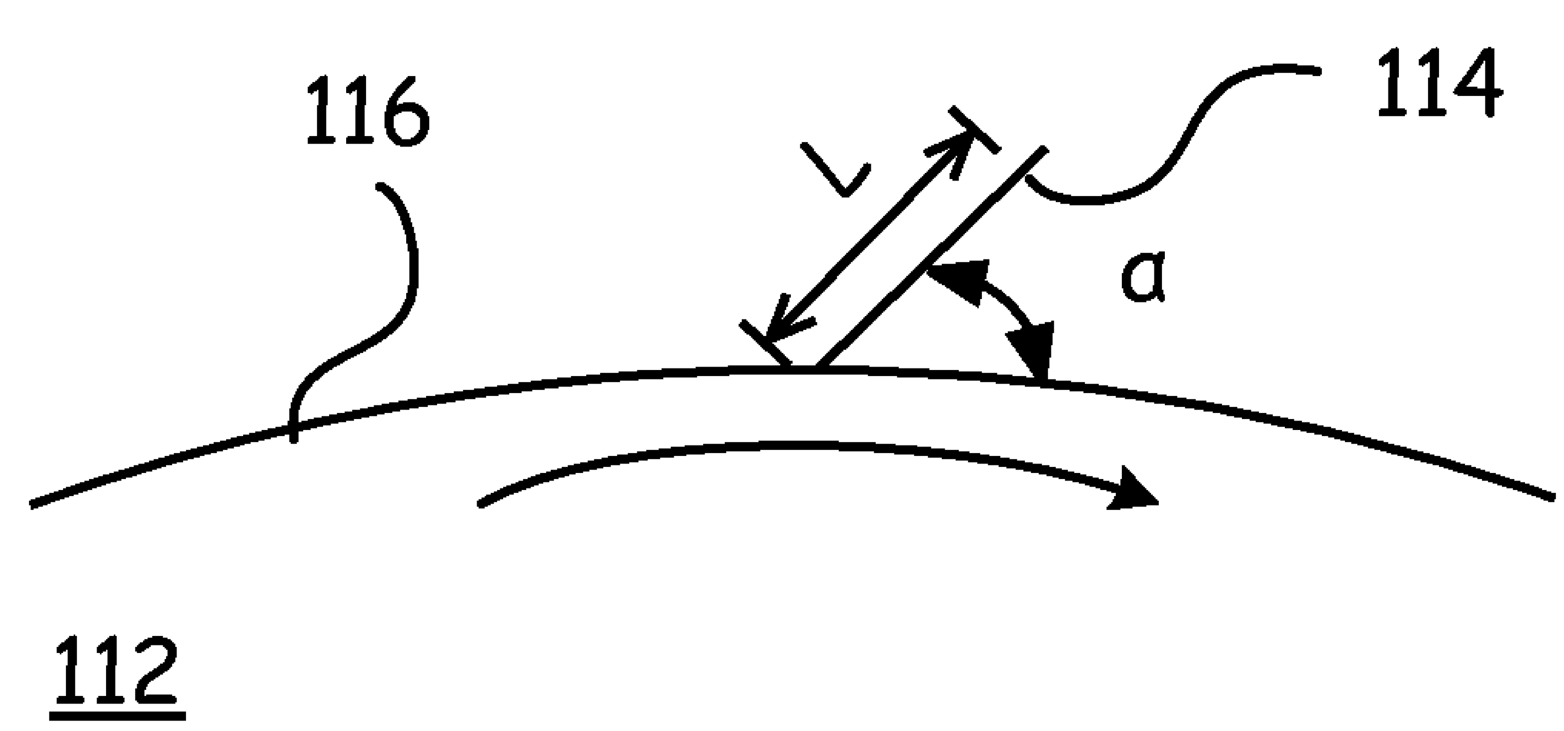

Fig. 3

TRASH SEPARATOR

FIELD

This invention relates to the field of fiber quality measurement. More particularly, this invention relates to separating non-fiber entities (such as trash) from fibers (such as cotton).

BACKGROUND

Natural and man-made fibers are routinely assessed for a variety of different properties, so as to grade the fiber samples. These properties include things such as fiber length, strength, color, moisture content, crimp, fineness, and non-fiber content. For example, measuring the properties of cotton fiber so as to provide a grade for the quality of the cotton is an important step in determining the value of the fibers.

Measuring the non-fiber content of a fiber sample is accomplished by separating the fibers in a fiber sample from as much of the non-fiber content (often generally referred to as trash) in the fiber sample as possible, and weighing or otherwise quantifying at least two of: (1) the original fiber sample, (2) the fibers that were separated from the original fiber sample, and (3) the trash that was separated from the original fiber sample. Typically, anything that is not the desired fibers themselves is considered non-fiber content, and designated as trash.

Unfortunately, prior art separators typically allow significant quantities of fibers to remain mixed in with the separated trash, thus making it difficult to determine the total trash content of the original fiber sample.

What is needed, therefore, is a system that reduces problems such as those described above, at least in part.

SUMMARY

The above and other needs are met by a separation apparatus for processing a fiber sample that includes both fibers and trash, and includes a separation cylinder rotating in a first direction and receiving the fiber sample. The separation cylinder has a cylindrical surface with a length extending along a longitudinal axis. Rigid protuberances with distal ends extend from the cylindrical surface. The protuberances selectively engage and retain the fibers of the fiber sample. A knife edge extends parallel to the longitudinal axis and along substantially the entire length of an underside of the separation cylinder, and is disposed adjacent the distal ends of the protuberances, for selectively removing from the fiber sample the trash that is not retained by the protuberances. The trash is thereby separated from the fiber sample along a substantially downward direction. A counter-flow of air moving at a first velocity in a substantially upward direction is directed towards the underside of the separation cylinder, where the first velocity is sufficient for the counter-flow of air to draw the fibers that are not retained by the protuberances up toward the separation cylinder, and yet is insufficient to prevent gravity from pulling the trash downward through the counter-flow of air. A collection surface receives the trash that falls downward through the counter-flow of air.

In various embodiments according to this aspect of the invention, a scale measures the weight of the trash received by the collection surface. In some embodiments a correction module, such as one including a camera, visually detects fibers on the collection surface and subtracts an estimated weight of the detected fibers from the weight of the trash. In some embodiments a feed roller is disposed adjacent the separation cylinder and in advance of the knife edge relative to the first direction of rotation of the separation cylinder. The feed roller rotates in the first direction and presents the fiber sample to the separation cylinder at a position where the feed roller tangential direction of motion is substantially opposite to the separation cylinder tangential direction of motion.

In some embodiments a vacuum source is disposed adjacent the separation cylinder and behind the knife edge relative to the first direction of rotation of the separation cylinder. The vacuum source draws an airflow away from the cylindrical surface of the separation cylinder and removes the fibers from the protuberances. In some embodiments the protuberances extend from the cylindrical surface of the separation cylinder at an angle that is inclined toward the first direction of rotation.

According to another aspect of the invention, there is described a method for processing a fiber sample that includes both fibers and trash. Fibers of the fiber sample are selectively engaged and retained with a pinned cylinder that is rotating in a first direction, and has a cylindrical surface with a length extending along a longitudinal axis, with rigid pins having distal ends extending from the cylindrical surface. Trash is selectively removed from the fiber sample that is not retained by the pins in a downward direction with a knife edge extending parallel to the longitudinal axis and along substantially the entire length of an underside of the pinned cylinder, and disposed adjacent the distal ends of the pins. The floating fibers and trash are contacted with a counter-flow of air moving at a first velocity in a substantially upward direction towards the underside of the pinned cylinder, the first velocity sufficient for the counter-flow of air to draw the fibers that are not retained by the pins up toward the pinned cylinder. The first velocity is insufficient to prevent gravity from pulling the trash downward through the counter-flow of air. The trash that has fallen downward through the counter-flow of air is collected on a collection surface.

In various embodiments according to this aspect of the invention, the weight of the trash collected on the collection surface is measured. In some embodiments the fibers on the collection surface are visually detected with a correction module and an estimated weight of the fibers is subtracted from the weight of the trash. In some embodiments the fiber sample is presented to the pinned cylinder with a feed roller that is disposed adjacent the pinned cylinder and in advance of the knife edge relative to the first direction of rotation of the pinned cylinder. The feed roller rotates in the first direction and at a position where a feed roller tangential direction of motion is substantially opposite to a pinned cylinder tangential direction of motion.

In some embodiments an air flow is drawn away from the cylindrical surface of the pinned cylinder and the fibers are removed from the pins with a vacuum source disposed adjacent the pinned cylinder and behind the knife edge relative to the first direction of rotation of the pinned cylinder.

DRAWINGS

Further advantages of the invention are apparent by reference to the detailed description when considered in conjunction with the figures, which are not to scale so as to more clearly show the details, wherein like reference numbers indicate like elements throughout the several views, and wherein:

FIG. **1** depicts a trash separation apparatus from an end view of a separation cylinder according to an embodiment of the present disclosure.

FIG. **2** is a front view of a separation cylinder according to an embodiment of the present invention.

FIG. **3** is a side view of a separation cylinder and protuberances according to an embodiment of the present invention.

DESCRIPTION

With reference now to the figures, there are described various embodiments of a trash separator **100**, which is operable for separating trash particles **104** from fibers **106** in a fiber sample **102**. The fiber sample **102** may take various forms. In one embodiment, the fiber sample **102** is cotton, but in other embodiments the fiber sample **102** is formed of other natural or man-made fibers, or combinations thereof. The fiber sample **102** includes both individual fibers **106** and trash particles **104**.

In the embodiment depicted, the fiber sample **102** is presented to the trash separator **100** by feeding it between a feed roller **108** and a feed surface, or feed plate, **110**. The feed roller **108** rotates in a first direction (such as indicated in FIG. **1**) at a rotational rate of from about one rotation per minute to about four rotations per minute, such that the fiber sample **102** is pulled between the feed roller **108** and the feed surface **110**. In the embodiment as depicted, the feed roller **108** rotates in a clockwise direction, pulling the fiber sample **102** toward a separation cylinder **112**, which also rotates in the first direction (clockwise, as indicated in this embodiment as depicted) and at a rotational rate of from about one thousand rotations per minute to about two thousand rotations per minute.

In some embodiments the feed roller **108** is formed of a smooth-surfaced soft-matter coating (such as rubber) on a steel shaft, which adjusts to the varying thickness of the fiber sample **102** and retains the fiber sample **102** along the feed roller **108** axis, to prevent premature release of the fiber sample **102**. The feed roller **108** is adjustable to make the gap between the feed roller **108** and the feed surface **110** larger or smaller, such as according to the varying thickness of the fiber sample **102**. Therefore, the feed roller **108** holds the fiber sample **102** firmly while being combed by the separation cylinder **112**, effectively reducing the generation of unopened fiber clumps that might be pulled out and thrown down.

FIG. **2** depicts a front view of the separation cylinder **112**. In some embodiments the separation cylinder **112** has a length of from about 250 millimeters to about 800 millimeters, and a diameter of from about 100 millimeters to about 300 millimeters. In some embodiments the feed roller **108** has a length that is substantially equal to that of the separation cylinder **112**, and a diameter of from about thirty-seven millimeters to about seventy-five millimeters.

The feed roller **108** and the separation cylinder **112** are disposed adjacent one another at a first position, at which the tangential direction of motion of the feed roller **108** and the tangential direction of motion of the separation cylinder **112** are substantially opposite one another. The tangential direction of motion is defined as the direction of travel of a point on a surface of a rotating body. The feed surface **110** keeps the fiber sample **102** engaged by the feed roller **108** until the fiber sample **102** is disposed at substantially the first position (as opposed to releasing it much earlier), at which position the fiber sample **102** is contacted by the separation cylinder **112**, which is moving in the opposite tangential direction. These opposing directions of motion between the feed roller **108** and the separation cylinder **112** produce a severe sheering force on the fiber sample **102** that pulls it apart.

As the fiber sample **102** separates, the fibers **106** tend to be predominantly engaged and retained by the protuberances **114** of the separation cylinder **112**, while the trash particles **104** of the fiber sample **102** tend to remain predominantly unengaged by the protuberances **114**. Some of the trash **104** is separated from the fibers **106** at this point, as the protuberances **114** tend to bat the trash **104** in a downward direction and away from the fibers **106** that are engaged by the protuberances **114**. In some embodiments the protuberances **114** are saw-tooth structures, and in other embodiment the protuberances **114** are pins. In some embodiments, a combination of saw teeth and pins comprise the protuberances **114**.

In some embodiments, and as depicted in more detail in FIG. **3**, the protuberances **114** protrude from the cylindrical surface **116** of the separation cylinder **112** at an angle α in relation to the surface **116** of the separation cylinder **112**. The angle α is from about fifty degrees to about ninety degrees, and leans into the direction of rotation of the separation cylinder **112**. The length of the protuberances is from about two millimeters to about four millimeters.

In some embodiments the protuberances **114** are evenly spaced-apart across the surface **116** of the separation cylinder **112**. In some embodiments the spacing of the protuberances **114** across the surface **116** depends upon the type of fiber sample **102** being tested. For example, for one type of fiber sample **102** it may be desirable to place the protuberances **114** relatively further apart, while with another fiber sample **102** it may be desirable to place the protuberances **114** relatively closer together.

A knife **118** is disposed adjacent the separation cylinder **112**, such that the knife **118** extends parallel to the longitudinal axis and along substantially the entire length of the separation cylinder **112**. The knife **118** is positioned such that any trash **104** that is not entrained within the protuberances **114** is predominantly removed from the fibers **106** that are entrained within the protuberances **114**, and is deflected in a downward direction towards a counter-flow chamber **120**. In some embodiments, the edge of the knife **118** is disposed very close to the ends of the protuberances **114**. In some embodiments the edge of the knife **118** is straight and does not interdigitated the protuberances **114**.

Some embodiments include a lint deflector **134**, such as made of parallel and bent metal tines disposed along the direction of rotation of the separation cylinder **112**, which help prevent large clumps of material from falling. The lint deflector **134** works as a filter or screen to help prevent clumps of fibers **106** from dropping to the trash collection surface **126**, but let the trash **104** to pass through. The tines of the lint deflector **134** in one embodiment are parallel to each other and bent along the direction of the air flow. The tines in one embodiment deflect the fiber clumps with a size larger than about six millimeters without catching individual fibers **106**. The ends of the wires of the lint deflector **134** are open near the vacuum source **124** so that material that is caught by the lint deflector **134** is not retained by the lint deflector **134**, but instead will be drawn off by the vacuum source **124**.

The counter-flow chamber **120** provides an upward-directed airflow **122** that enters the counter-flow chamber **120** at the bottom of the counter-flow chamber **120** (as indicated in FIG. **1**), such that the airflow **122** is in an upward direction and substantially opposite to the direction of travel of the falling trash particles **104** and the few fibers **106** that were not originally engaged by the protuberances **114**. The purpose of the airflow **122**, which in some embodiments is generated by the vacuum source **124** and air flow from the rotating separation cylinder **112**, is to blow such non-engaged fibers **106** back up toward the bottom of the separation cylinder **112**, such that they engage with the protuberances **114**, or are carried by the air flow from the rotating separation cylinder **112** to the vacuum source **124**, and do not continue down through the counter-flow chamber **120**. The upwardly directed airflow **122** changes the trajectory of the falling fibers **106** by about

180 degrees, whereas an airflow in any other direction, such as a cross-flow of air, would only change the fiber **106** trajectory by no more than about ninety degrees.

To accomplish this, the airflow **122** moves at a first velocity such that any fibers **106** that attain the counter-flow chamber **120** are generally lofted upwards by the airflow **122** toward the separation cylinder **112**. However, the first velocity of the airflow **122** is generally insufficient to prevent gravity or other forces, such as momentum, from drawing the trash particles **104** downward through the counter-flow chamber **120**.

In some embodiments the airflow **122** through the counter-flow chamber **120** is adjustable from about twenty-five meters per minute to about sixty meters per minute, such as depending upon the type of fiber sample **102** being tested. For example, when a heavier fiber **106** is being tested, then the airflow **122** may flow through the counter-flow chamber **120** at a relatively faster rate, to reduce the occurrence of the heavier fibers falling through the counter-flow chamber **120**. On the other hand, when a lighter fiber **104** is being tested, the airflow **122** may flow through the counter-flow chamber **120** at a relatively slower rate, to reduce the occurrence of lighter trash particles being drawn upwards toward the separation cylinder **112** and the vacuum source **124**.

In some embodiments, a vacuum source **124** is disposed adjacent the separation cylinder **112**. In some embodiments, the vacuum source **124** is controlled to maintain a stable air flow **122**. The vacuum source **124** draws an airflow away from the separation cylinder **112**, and removes the fibers **106** that were engaged by the protuberances **114** from the separation cylinder **112**. The vacuum source **124** is disposed after the knife **118**, relative to the direction of rotation of the separation cylinder **112**, as depicted. In some embodiments the vacuum source **124** creates the air flow **122**.

In the embodiment as depicted, the trash particles **104** that fall down through the counter-flow chamber **120** then fall through a stilling chamber **132** in which the air is substantially stagnant, in that there is no forced air flow in any direction. The trash particles **104** fall down through the chamber **132** and onto a collection surface **126**. Because of the counter-flow of air **122**, few or no fibers **106** attain the collection surface **126**. Thus, the apparatus **100** achieves a highly successful separation of the fibers **106** and the trash **104** of the fiber sample **102**. Some embodiments include a trash vacuum wiper bar **138** to remove trash **104** (and fibers **106**, as needed) from the tray **126**.

The counter-flow chamber **120** and stilling chamber **132** have an opening between them that allows air to enter the counter-flow chamber **120** and flow upward to the vacuum source **124**. The counter-flow of air **122** works as a filter for the freely flying loose fibers **106** to prevent them from dropping to the trash collection surface **126**.

In some embodiments, the trash content of the fiber sample **102** is determined by measuring the mass of the fiber sample **102** before it is processed through the trash separator **100**, and then measuring the mass of the trash particles **104**, such as by weighing the collection surface **126** and the trash **104** disposed thereon. As desired, the trash **104** content as a percentage of the total weight of the fiber sample **102** can be calculated. In some embodiments, the mass of the fibers **106** that are eventually drawn off by the vacuum source **124** can also be measured and used in similar calculations. In some embodiments, an air curtain plate **136** is disposed between the counter-flow chamber **120** and the stilling chamber **132** or between the stilling chamber **132** and the collection surface **126**, and is used to seal off the collection surface **126** to minimize air currents **122** when the trash **104** is being weighed.

Some fibers **106** still might attain the collection surface **126**. In some embodiments, these fibers **106** are manually removed before weighing the collection surface **126**. In other embodiments, the weight of the fibers **106** on the collection surface is determined with a correction module **130** that visually detects the fibers **106** on the collection surface **126**, and estimates the weight of the detected fibers **106**, and subtracts that estimated weight from the weight of the collection surface **126**, thus yielding the weight of the trash particles **104**.

The foregoing description of embodiments for this invention has been presented for purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form disclosed. Obvious modifications or variations are possible in light of the above teachings. The embodiments are chosen and described in an effort to provide illustrations of the principles of the invention and its practical application, and to thereby enable one of ordinary skill in the art to utilize the invention in various embodiments and with various modifications as are suited to the particular use contemplated. All such modifications and variations are within the scope of the invention as determined by the appended claims when interpreted in accordance with the breadth to which they are fairly, legally, and equitably entitled.

The invention claimed is:

1. A separation apparatus for processing a fiber sample that includes both fibers and trash, the separation apparatus comprising:

a pinned cylinder for rotating in a first direction and receiving the fiber sample, the pinned cylinder having a cylindrical surface with a length extending along a longitudinal axis, and rigid pins having distal ends extending from the cylindrical surface, the pins for selectively engaging and retaining the fibers of the fiber sample,

a knife edge extending parallel to the longitudinal axis and along substantially the entire length of an underside of the pinned cylinder, and disposed adjacent the distal ends of the pins, for selectively removing from the fiber sample the trash that is not retained by the pins, the trash thereby separating from the fiber sample along a substantially downward direction, a counter-flow of air moving at a first velocity in a substantially upward direction towards the underside of the pinned cylinder, the first velocity sufficient for the counter-flow of air to blow the fibers that are not originally retained by the pins up toward the bottom of the pinned cylinder and thereby engaging the fibers with the pinned cylinder, and the first velocity insufficient to prevent gravity from pulling the trash downward through the counter-flow of air, and

a collection surface for receiving the trash that has fallen downward through the counter-flow of air.

2. The separation apparatus of claim **1**, further comprising a scale for measuring the weight of the trash received by the collection surface.

3. The separation apparatus of claim **2**, further comprising a correction module for visually detecting fibers on the collection surface and subtracting an estimated weight of the detected fibers from the weight of the trash.

4. The separation apparatus of claim **1**, further comprising a feed roller disposed adjacent the pinned cylinder and in advance of the knife edge relative to the first direction of rotation of the pinned cylinder, the feed roller for rotating in the first direction and presenting the fiber sample to the pinned cylinder at a position where a feed roller tangential direction of motion is substantially opposite to a pinned cylinder tangential direction of motion.

5. The separation apparatus of claim **1**, further comprising a vacuum source disposed adjacent the pinned cylinder and behind the knife edge relative to the first direction of rotation of the pinned cylinder, the vacuum source for drawing an air flow away from the cylindrical surface of the pinned cylinder and removing the fibers from the pins.

6. The separation apparatus of claim **5**, further comprising a lint deflector made of bent and parallel tines disposed along the pinned cylinder in the direction of rotation to prevent clumps of the fiber sample from falling to the collection surface and to guide clumps along the tines and back to the pinned cylinder and vacuum source.

7. The separation apparatus of claim **1**, wherein the pins extend from the cylindrical surface of the pinned cylinder at an angle that is inclined toward the first direction of rotation.

8. The separation apparatus of claim **1**, wherein the protrusions comprise saw teeth.

9. The separation apparatus of claim **1**, wherein the protrusions comprise pins.

10. A separation apparatus for processing a fiber sample that includes both fibers and trash, the separation apparatus comprising:

- a separation cylinder for rotating in a first direction and receiving the fiber sample, the separation cylinder having a cylindrical surface with a length extending along a longitudinal axis, and rigid protrusions having distal ends extending from the cylindrical surface, the protrusions for selectively engaging and retaining the fibers of the fiber sample,
- a knife edge extending parallel to the longitudinal axis and along substantially the entire length of an underside of the separation cylinder, and disposed adjacent the distal ends of the protrusions, for selectively removing from the fiber sample the trash that is not retained by the protrusions, the trash thereby separating from the fiber sample along a substantially downward direction,
- a counter-flow of air moving at a first velocity in a substantially upward direction towards the underside of the separation cylinder, the first velocity sufficient for the counter-flow of air to blow the fibers that are not originally retained by the protrusions up toward the bottom of the separation cylinder and thereby engaging the fibers with the separation cylinder, and the first velocity insufficient to prevent gravity from pulling the trash downward through the counter-flow of air, and
- a collection surface for receiving the trash that has fallen downward through the counter-flow of air.

11. The separation apparatus of claim **10**, further comprising a scale for measuring the weight of the trash received by the collection surface.

12. The separation apparatus of claim **11**, further comprising a correction module for visually detecting fibers on the collection surface and subtracting an estimated weight of the detected fibers from the weight of the trash.

13. The separation apparatus of claim **10**, further comprising a feed roller disposed adjacent the separation cylinder and in advance of the knife edge relative to the first direction of rotation of the separation cylinder, the feed roller for rotating in the first direction and presenting the fiber sample to the separation cylinder at a position where a feed roller tangential direction of motion is substantially opposite to a separation cylinder tangential direction of motion.

14. The separation apparatus of claim **10**, further comprising a vacuum source disposed adjacent the separation cylinder and behind the knife edge relative to the first direction of rotation of the separation cylinder, the vacuum source for drawing an air flow away from the cylindrical surface of the separation cylinder and removing the fibers from the protrusions.

15. The separation apparatus of claim **14**, further comprising a lint deflector made of bent and parallel tines disposed along the separation cylinder in the direction of rotation to prevent clumps of the fiber sample from falling to the collection surface and to guide clumps along the tines and back to the separation cylinder and vacuum source.

16. The separation apparatus of claim **10**, wherein the protrusions extend from the cylindrical surface of the separation cylinder at an angle that is inclined toward the first direction of rotation.

17. A method for processing a fiber sample that includes both fibers and trash, the method comprising the steps of:

- selectively engaging and retaining fibers of the fiber sample with a separation cylinder, the separation cylinder rotating in a first direction and having a cylindrical surface with a length extending along a longitudinal axis, and rigid pins having distal ends extending from the cylindrical surface,
- selectively removing from the fiber sample trash that is not retained by the pins in a downward direction with a knife edge extending parallel to the longitudinal axis and along substantially the entire length of an underside of the separation cylinder, and disposed adjacent the distal ends of the pins,
- contacting the fibers and trash with a counter-flow of air moving at a first velocity in a substantially upward direction towards the underside of the separation cylinder, the first velocity sufficient for the counter-flow of air to blow the fibers that are not originally retained by the pins up toward the bottom of the separation cylinder and thereby engaging the fibers with the separation cylinder, and the first velocity insufficient to prevent gravity from pulling the trash downward through the counter-flow of air, and
- collecting on a collection surface the trash that has fallen downward through the counter-flow of air.

18. The method of claim **17**, further comprising measuring the weight of the trash collected on the collection surface.

19. The method of claim **18**, further comprising:

- visually detecting fibers on the collection surface with a correction module, and subtracting an estimated weight of the fibers from the weight of the trash.

20. The method of claim **17**, further comprising presenting the fiber sample to the separation cylinder with a feed roller that is disposed adjacent the separation cylinder and in advance of the knife edge relative to the first direction of rotation of the separation cylinder, the feed roller rotating in the first direction and at a position where a feed roller tangential direction of motion is substantially opposite to a separation cylinder tangential direction of motion.

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